SYNTHESIS AND CHARACTERIZATION OF PURE AND DOPED CONDUCTING AND SEMICONDUCTING MATERIALS

Summary of

THESIS

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Chapter 1 deals with the brief introduction of materials, their types and applications. In this chapter, we have discussed about basics of materials and three conducting polymers including polythiophene (PTh), polyaniline (PAni) and polypyrrole (PPy) and their metal nanocomposites. The metal dopants such as Al₂O₃, CuO and TiO₂ have been discussed in the present work. It also deals the discussion of deposition techniques of the thin films as well as characterization techniques. It also contains the organization and objective of thesis.

In Chapter 2 undoped and Al₂O₃/polythiophene nanocomposites have been synthesized by chemical oxidation method. All the samples are characterized by X-ray diffraction (XRD), Scanning electron microscopy (SEM), Ultraviolet visible Spectroscopy (UV-vis), Photoluminescence (PL) spectra and Fourier transform infra red (FTIR) spectroscopy. XRD spectra show the polycrystalline nature of all the samples. SEM images are indicating formation of spherical shape of nanostructures. As-synthesized samples of undoped polythiophene and Al₂O₃/PTh nanocomposites exhibit many pores on the surface of nanostructures. Synthesis of Al₂O₃ polythiophene composite material is confirmed by FTIR spectroscopy. UV-visible absorption spectra show absorption peak at around 300 nm which is due to π- π* inter-band-transition of PTh rings. A small change in optical absorption spectra is observed which can be associated with the degree of oxidation. PL spectra exhibit mainly three visible emission peaks at around 462 nm, 490 nm and 522 nm. The two emission peaks 462 nm and 490 nm in the Soret band region whereas single peak at 522 nm in the Q band emission. The intensity and peak position of polythiophene have been randomly changed with amount of Al₂O₃ dopant.
Chapter 3 deals with synthesis of undoped and CuO/PAni nanocomposite by the chemical oxidation method at room temperature and their characterizations. The prepared samples have been characterized by XRD, SEM, FTIR, UV-visible and photoluminescence spectroscopy. XRD spectra show weak crystalline quality of all the samples, whereas the PAni synthesized is amorphous in nature. The scanning electron microscopy images of all the samples show granular coral like structure. The study of FTIR spectra confirm the formation of conducting PAni and also suggests that doping of CuO in PAni does not affect the structures. The UV–visible absorption spectra of the solutions of all the samples contain some peak at 305 nm. The observed bathochromic shift at the intense absorption band 305 nm is due to the π-π* transition of benzenoid ring. The PL spectra of 0, 2, 4, 6 and 8 wt% CuO/PAni samples show peaks in visible emission region which at around 362 nm, 405 nm in violet region 459 nm, 486 nm in blue region and 528 nm in green region.

In Chapter 4, we have synthesized undoped and Al₂O₃ doped PPpy samples by chemical oxidation method. The prepared samples have been characterized by XRD, SEM, FTIR, UV-Vis and PL. X-ray diffraction patterns of PPpy/Al₂O₃ nanocomposites result show several broad peaks while undoped sample shows only one single peak indicating poor crystalline phase of PPpy. In the SEM images, the results were found granular coral like structures. As a characteristic of Polypyrrrole, secondary nucleation also takes place because of which the granular coral like particles come together to form aggregates. We noticed that as the amount of Al₂O₃ was increased; the number of pores and the size of pores were also increased, which is very important for sensing. The study of FTIR spectra confirms the formation of PPpy and also suggests that doping
of $\text{Al}_2\text{O}_3$ in PPy does not affect its structure. The UV absorption can significantly determine the interaction between the $\text{Al}_2\text{O}_3$ and PPy. Solutions of all the samples show peak, which oriented around 306 nm. The peak at 306 nm is associated with the exciton transition of $\pi-\pi^*$. PL shows the main emission band of the nanocomposites, located at 365 nm with two shoulders at 473 and 533 nm. The direct band gap energies of the PPy/$\text{Al}_2\text{O}_3$ nanocomposite of different ratios are found as 3.09 and 2.19 eV. The band gap gets decreased due to increased content of $\text{Al}_2\text{O}_3$ nano particles.

**In chapter 5**, we have synthesized undoped and $\text{Al}_2\text{O}_3$ doped PAni samples by the chemical oxidation method. The prepared samples have been characterized by XRD, SEM, FTIR, UV-Vis and PL. The XRD spectra shows a peak around 25° which confirm the synthesis of PAni and another peak at 55.08° for 8 wt% $\text{Al}_2\text{O}_3$ doped PAni which as the confirmations of successful doping in PAni. The study of FTIR spectra confirms the formation of PAni and also suggests that doping of $\text{Al}_2\text{O}_3$ in PAni does not affect its structure. The SEM images of all the samples show coral like structure. UV spectra show single broad peak at around 305 nm and small peak at around 450 nm. The peak 305 nm is associated with the exciton transition of $\pi-\pi^*$. The longer wavelength peak at around 450 nm can be associated to the transition between benzenoid to quinoid rings. PL spectra recorded with excitation wavelength 325 nm show a strong UV peak at 384 nm with weak visible peak at 484 nm and 527 nm.

**In Chapter 6**, we have prepared undoped PPy and $\text{TiO}_2$ doped PPy thin films by sol-gel spin coating method. The prepared samples have been characterized by XRD, SEM, FTIR, UV-Vis and PL. XRD spectra show the weak crystalline quality of all the samples. SEM images show the sphere shape of nanostructures. The amount of $\text{TiO}_2$ doping increases the
number of pores as well as size of the pores that play a very important role in sensing of gas. The study of FTIR spectra confirms the formation of conducting PPy which suggests that doping of TiO$_2$ in PPy does not affect its structures. All the samples of PPy and PPy/TiO$_2$ nanocomposites thin films show the peak at 309 nm which is assigned to the $\pi$-$\pi^*$ transition or the excitation transition. The PL spectra of PPy and TiO$_2$ doped PPy show three main peaks, first is in UV region around at 368 nm, second broad peak in visible region around 480 nm and another sharp peak at around 530 nm in green region.

**Chapter 7** deals with the conclusion of all the work and the recommendations for further work.